International Journal of Institutions and Economies
Vol. 1, No. 1, April 2009, pp. 134-155

The National Technology System Framework: Sanjaya Lall's Contribution to Appreciative Theory

Mammo Muchie
Tshawne University of Technology/
Aalborg University
Email: muchiem@tut.ac.za, mammo@ihis.aau.dk

Angathevar Baskaran
Middlesex University
Business School
Email: a.t.baskaran@mdx.ac.uk

Abstract: Sanjaya Lall has grappled with the dilemmas of development by concentrating his life-long research on technology, international trade, manufacturing and industrial development largely but not exclusively in the developing world. He constructed taxonomy on low technology; resource based products, medium technology intensive and high tech intensive products and tried to measure the challenges, opportunities and difficulties for resource based producers like the countries in Sub-Saharan Africa to enter into medium and high technology intensive manufactures. The rich empirical work undertaken on the developing economies, South East Asia and others has led him to formulate the appreciative concept of National Technology System (NTS). In this paper we distinguish between the development and relationship between formal and appreciative theories in general and the NTS and national system of innovation (NSI) concepts in particular. We shall attempt to examine, compare and contrast broadly Sanjay Lall's appreciative NTS concept in relation to the national innovation system approach in the context of the debate for generating the appropriate and relevant heuristics to get clearer comprehension of the dynamics and processes involved in both technology acquisition and efficiency for economic competitiveness and development.

Keywords: National technology system, triple helix, formal theory, appreciative theory

JEL classifications: A13, B15, B52, D02

1. Introduction

"[NTS] reflects the fact that they (developing economies) are seldom 'innovators' in a narrow sense, but they crucially need to be able to acquire the foreign technologies relevant to their competitiveness, absorb them, adapt and improve them constantly as conditions change. Following this notion of innovation and technical change, it is developed a concept of National Technology System" (Lall and Pietrobelli, 2002).

There are three appreciative approaches that have come out from the innovation studies literature connected to the problem of technology creation and acquisition. The first and the most popularized is the national innovation system or national systems of innovation (NSI) defined originally by Freeman as the "network of institutions in the public and private sectors whose activities and actions initiate, import, modify and diffuse new technologies" (Freeman, 1987; OECD, 1997). The key concepts are related to initiating or creating innovation for diffusion or to importing and modifying in order to also diffuse new innovations though primarily acquired externally. The spectrum includes from initiating and creating new technologies to importing and appropriation of created new technologies. The first NSI provides the conceptual approach or framework for using the national innovation system for all economies at various stages of development without dividing them first into developed and developed economies (List, 1885; Freeman, 1982, 1987, 1995, 2002; Lundvall, 1988, 1992; Nelson, 1993; Edquist, 1997a, 1997b; OECD, 1999, 2005).

To be sure List was concerned with industrial and economic catching up which is not to be equated specifically with either developing or developed countries. "Catch up relates to the ability of a single country to narrow the gap in productivity and income vis-à-vis the leader country" (Fagerberg and Godinho, 2005, p. 514). Though many catch-up countries are in the developing world today, initially it arose to explain the catch up efforts of countries like Germany with England as the leader of the time (Abramovitz, 1986; Gerschenkron, 1962; Chang, 2002; Johnson, 1982; Lall, 2000; Dosi et al., 1988). The catch up concept goes as complementary with the NSI approach and thus broadly forms part of the literature in this category.

The second is the approach that appreciates the empirical specificities and contexts of developing countries first by insisting that conceptual elaboration benefits from such *a priori* empirical appreciation or substantiation before and in order to formulate a conception that captures the key domains that need to be identified, specified and relevant for enabling developing economies to absorb and adapt foreign technology (Lall, 2001, 2003; Lall and Pietrobelli, 2002; UNCTAD, 2003; UNIDO, 2002).

The third is the approach that tries to broaden the national system of innovation to include directly problems and challenges of development and underdevelopment. This new approach, which has been stimulated by the Globelics network to link modes of innovation systems to the processes of economic development, tries to bridge the gap that may exist between innovation system dynamics and economic development by focusing on the determinants of innovative, learning and competence building activities in the development processes (Lundvall et al., 2002). This approach tries to combine innovation creation on the one hand and technology acquisition or absorption and adoption on the other in order to attain technology efficiencies

to improve economic competitiveness for accelerating the development process forward by combining the creation of innovation or supply side, and absorption and demand side concerns (Edquist, 2001; Lundvall et al., 2002; Muchie et al., 2003; Baskaran and Muchie, 2006, 2007, 2008). This conception wishes to build complementary and reinforcing relation between technology or innovation creation and technology or innovation acquisition from the technology leaders.

A related concept which deals with similar problematic is the triple helix concept of university-industry-government relations developed by Etzkowitz and Leysdesdorff to explain innovation in knowledge-based societies (Etzkowitz and Leydesdorff, 1997; Etzkowitz, 2002).[1] The triplet – university, industry and government – as helices suggests that innovation progresses in a spiral where multiple reciprocal relations are captured in the process of knowledge commercialization. The models from the triple helix highlight the internal transformation of each of the helices. Governments can turn either neo-liberal or authoritarian and can disengage or engage from supporting innovation or they can change the regulatory framework for knowledge creation or acquisition through changing the intellectual property or other incentives or disincentives as the case may be. The universities change into corporations from producing public knowledge to knowledge for private economic profit. Industry can engage more in mergers and acquisitions than innovation. And the interaction of each of the helices on one another may have positive or negative influence to their performance or productivities. New spheres of activities and intersecting institutions can emerge where university takes on the function of industry, and conversely industry takes the form of university and Government may define new roles to interact with the changed missions of each of the helices.

The main consequence from this model is two fold: market dominated economics privilege the economy. State dominated action privileges politics and power. Both tend, though not necessarily always, to relegate knowledge as subsidiary. A model which transcends both state and market is supposed to be the triple helix for releasing a new configuration of institutional forces for shaping and advancing innovation systems for promoting high-tech development.

The triple helix can also be extended like the national system of innovation to the context and challenges of developing countries, though much of the empirical work came from the industrial economies.[2] Unlike the Globelics research network which held all its conferences in the developing world, it looks the triple helix holds its conferences mainly in the industrialized countries.[3]

What is shared amongst these ranges of conceptual approaches is that they are all derived from empirical observations and regularities and not deduced from formal theory. They are all variants of appreciative theory.

They are all contributions from a process of induction and generalization of empirical regularities.

Where the difference lies is in the scope and coverage of the areas each of the approaches includes and excludes. Some approaches stress more on the problem of development and economic competitiveness of developing countries through the application of science, technology and innovation without excluding entirely others. Other approaches concentrate more on industrialized economies institutions and policies to absorb, modify and diffuse new technologies without excluding others. Others propose a global reach where what is independent is the understanding of the process of innovation, learning and competence building for economic growth, development, competitiveness, efficiency and productivity.

Figure 1 tries to capture the major aspects of different appreciative approaches in the innovation studies literature. What emerges perhaps as a difference amongst them is emphasis on the relationship between the difference on building internal capability for endogenous science and technology, and for absorbing new technology from the world technology circuits. Equally important, it relates also to the difference in development strategy that recommends not to be able to integrate technologically is likely to impact adversely, and those who are willing to go for setting up a national system of technology where the agency for development is mainly internally driven.

As these approaches belong to empirical appreciation to build the particular generalization made, a distinction between formal theory and appreciative theory will be useful to introduce to clarify further that what has been proposed as the NSI and NTS approaches is not general theory but variants of non-formal theorizing.

2. Formal Theory and Appreciative Theory for Developing an Alternative Economics Framework[4]

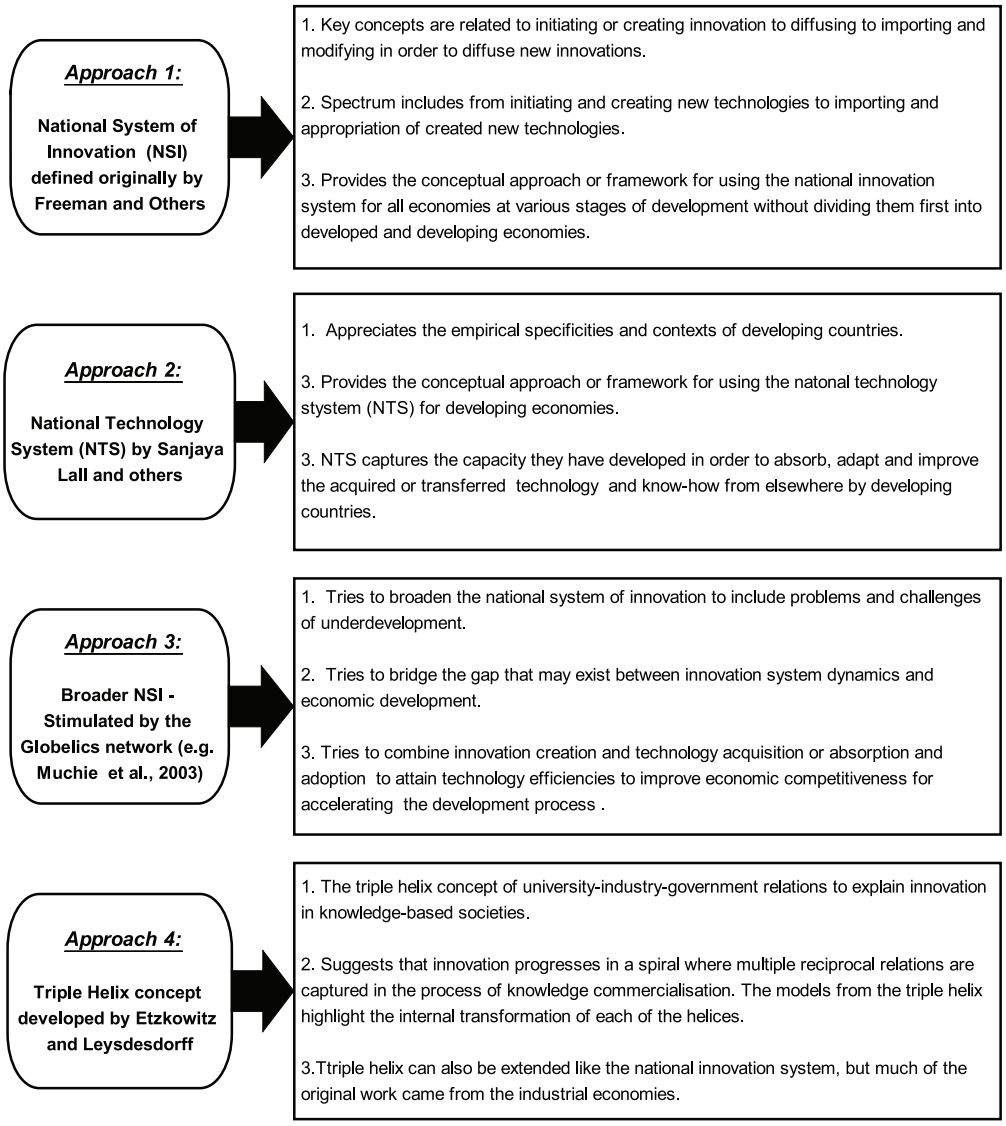
Nelson and Winter, in their pioneering work, define and distinguish formal and appreciative theory in economics as follows:

> A theory defines the economic variables and the relationships that are important to understand, gives a language for discussing these, and provides a mode of acceptable explanation (Nelson and Winter, 1982, p. 46).

Theory selects some phenomena as important or unimportant, peripheral or central, interesting or uninteresting, informed or ill-informed, sophisticated or unsophisticated by setting boundaries for inclusion and exclusion based on the relevance of the body of knowledge being sought to be generated.

When theory provides a 'framework for appreciation', it serves as a 'tool of inquiry'. The focus is on the "endeavour in which the theoretical tools are

Figure 1: Appreciative approaches in the innovation studies literature



applied" (*ibid.*). In formal theory, "the focus is on improving or extending or corroborating the tool itself…" (*ibid.*).

Formal theory is a source of ideas for appreciative theory and the vice versa. In general, drawing linkages or connection between these distinct forms of theorizing can enrich understanding of economic enquiry.

Nelson and Winter have proposed boldly an innovation framework to economic theory as an alternative to neoclassical framework (Nelson and Winter, 1982, pp. 128-130) building on earlier criticisms of mainstream economic thinking (mainly from the writings of Veblen, 1915, 1919 and Schumpeter, 1911, 1934, 1939, 1942) on modern dynamic economic theory building.

Today it appears that the formal theory is mainly pursued by the evolutionary economists. Appreciative theories based on empirical studies and research for policy selection or application has been pursued by the national innovation system perspectives and others in institutional and business economics. It seems to us there has been a proliferation of the appreciative variant of theorizing as part of the generation of the alternative framework on the economics of innovation.

There appears to be a sort of unwritten division of labour between the formal and appreciative theory where the formal theory of economic dynamics is dominated by evolutionary economists, and appreciative theorizing is largely populated by those who are empirically and policy orientated. It is not clear how much significant interaction and learning takes place between the formal theory and appreciative theory with mutual gain to each other. Formal theory concentrates mainly on economic structure. Appreciative theories focus mainly on system of innovation actors in their role in the processes of the development of economics of innovation dynamics and systems.

Both share the language brought out by the alternative economic theory such as: the use of evolutionary biological metaphors as opposed to static metaphors of mechanics in physics, they focus on institutions and change through new combination of routines. Above all they introduce innovation as deviation from routine behaviour capable of upsetting equilibrium by a process of creating and destroying in the process of economic growth.

Issues that seem to preoccupy much of the economists hoping to create an alternative to the mainstream neoclassical economic framework appear to be understanding economic growth; short term and long term economic firm level and/or national performance, micro and meso level competitiveness, firm and national level productivity, economic catching up, learning and knowledge creation and absorption in a given economic structure, and inter linkages between firm competitiveness and national competitiveness and productivity, symmetry and system building such as national, sectoral and other types of innovation systems. Since innovation is characterized by the process of creating and destroying, some economists including Veblen earlier on have not been open to the notion of innovation systems and symmetry. They focus more on asymmetry and system breaks than makes associating innovation more or less with a dynamic that disrupts systems and symmetry rather than the opposite.

Regardless of the scepticism, the system perspective is important in the need to choose interactions that enter into the economics of innovation to generate outcomes and impacts that are pre-imagined. The real processes may deviate from what may be desirable. That does not invalidate the choice of how innovation systems emerge and are formed by the interaction

of the structures, institutions, policies, knowledge and incentives in given environments and situations.

Regardless of whether system building or not, the national system of innovation perspective has been popularized. It has constituted perhaps a significant development of appreciative theorizing. Its main inquiry is to understand the variations or differences in the innovation performance of nations that enters into explaining the long-term economic performance, national productivity measured in such macroeconomic variables as GDP and national competitiveness. The degree to which micro-level firm innovative capability, performance and competitiveness can be aggregated to contribute to national innovative productivity, performance and competition has been analytically contentious.

A related concern is to emphasize first the interactions and capabilities of policies, institutions and incentives built primarily for acquiring new technologies to integrate with those in the lead of controlling world technology circuits or to try to emphasize interactions and capabilities for creating endogenous innovation for acquiring independence in integrating within the world technology circuits.

These varied emphases have led to different conceptual formulations, and one of the most significant concepts is the National Technology System (NTS) by Sanjaya Lall. The national innovation system is broader addressing mainly the institutions, policies, incentives and practices that interact both to *produce*, and *diffuse* new technology.

3. Sanjaya Lall's Conception of NTS

An important contribution of appreciative theorizing was undertaken by Sanjaya Lall who forwarded the concept of 'national technology systems' in order to capture two interrelated empirical observations. The first is to identify, select acquire and understand what are the technological dynamisms required to be competitive? The second is related to the understanding that many developing countries' industrial and technological performance is correlated to the capacity to use technological efficiency rather than technology creation per se. The assumption is that many developing countries are not the originators of radical or revolutionary innovation. They are users of created innovation elsewhere. Thus the national system of innovation or technology captures the capacity they have developed as interacting actors and institutions with policies and incentives in order to absorb, adapt and improve the acquired or transferred technology and know-how from elsewhere (Lall and Pietrobelli, 2005, pp. 311-342).

Sanjaya Lall goes further and defines development as "a process of integration *within* the world economy – rather than a process of parallel or

separate development. Integration is achieved through opening to flows of technology and capital" (Lall and Urata, 2003). The national technology system is not thus a means for promoting innovation only, but also it is a means "of facilitating of integration within the world's technological circuits" (*ibid.*).

So the national technological system is an empirically appreciated concept borne from the recognition that developing countries need to concentrate more in (a) building technological and financial capability by firms and public institutions, (b) improve policy settings, (c) manage the processes of diffusion of technologies and capital, and (d) build the requisite capability to be able to import, adopt, modify and adapt technologies to the development challenges to expedite national integration in the world's technology frontiers or circuits.

Sanjaya Lall's concept has been derived mainly from the appreciation, knowledge and understanding from the rich empirical work undertaken by himself and his research collaborators from developing economies on the challenges and problems of technology development and absorption.

The national system of innovation concept originated largely from the empirical context of the industrial economies such as USA, Germany, Japan and others and moved to newly industrializing countries later on, and right now attempts are being made to move it further to even the developing regions such as Sub-Saharan Africa (Muchie et al., 2003). It has now acquired recognition as a conceptual framework, if not a formal, theory for analyzing innovation processes (Edquist, 1997a, 1997b).[5] Given the origin and the context the main focus of the national innovation system is how different types of innovations are created and applied in economy and society by the combination of national policies, institutional capabilities and knowledge integration.

Appreciative theory in this innovation system genre has produced such terms as the knowledge-economy framework, the learning economy framework, and with the Globelics initiative, a further development has occurred for an explicit conceptual and empirical orientation of the insights from innovation processes to the economic development processes by focusing on how learning, innovation and competence building emerge and impact in the transformation processes of developing economies (Lundvall et al., 2002).

Whilst Sanjaya Lall's concept of the National Technology System (NTS) deals with the availability or lack of it of the capabilities of developing economies to absorb and adapt new technologies, the National System of Innovation (NSI) concentrates on the capabilities and contexts for the creation of the new technologies which Sanjaya Lall's NTS wishes to uptake and use to propel nations to promote development that integrates them with the technology producers rather than leaving them behind as marginalized. The NSI concentrates on the capabilities needed to make nations' producers

of science, technology and innovation regardless of whether this capability is internally generated or stimulated from imported high technology and radical innovation. Sanjaya Lall's NTS concentrates on the capabilities that make developing nations effective and efficient consumers of created new technologies. It leaves open or seems implicitly to acknowledge that the more countries build the institutional, knowledge and policy setting for turning acquired technology into effective productivity and competitive gains, then sooner or later there can be a spill over of knowledge to generate endogenized systems of innovation. Such an implicit trajectory appears to be suggested by the advocacy of the technology import by developing economies and technology export from the developed economies.

In other words, the more developing economies integrate with the world technology circuits, the more likely it is that they themselves can attain positions in the course of time as the leading new technology producers. Conversely the less able they are to integrate with the world new technology creators, the more unlikely it becomes for them to engage as innovation absorbers let alone to become producers. It means the direction to find alternative to integration with the world producers of new technologies by searching for a national development pattern is likely to be costly in the sense it may not take off and the opportunity cost of not striving to integrate can be high.

The difficulty with the NTS conceptual framing is that it makes preference for the development of the totality of policies, institutions, incentives and practices for integration with world technology circuits. The problem of building internal networks for the creation of innovation becomes dependent on the success of the integration effort. Where there is failure with integration, a developing country may not be able to have options internally to try to mobilize in order to create or absorb new technologies.

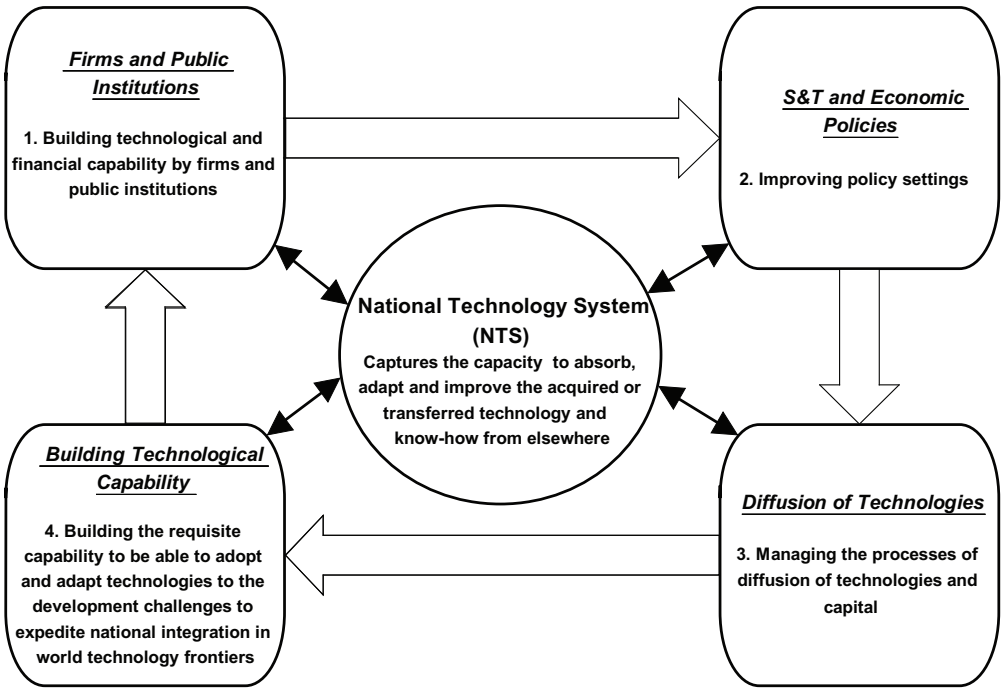
The Globelics research community appears to construct a synthesis where the spectrum of innovative potential does not exclude at the start developing countries from being themselves also innovators as well as absorbers by interacting with the technology producers. In other words in the Globelics conception the spectrum recognizes that developing countries can combine being innovators and producers of new technologies and also adopters of produced innovations from the world's major technology circuits. In fact being innovators facilitates absorption of new technologies, and conversely absorption of new technologies can strengthen the totality of institutions and practices to strengthen internal innovation creation. It is not one or the other, but to see both as linked and mutually reinforcing. For example, developing countries in Africa have rare resources which they often sell in raw form. If they can add value to it by letting raw material conversion into manufactures through innovative potential, they will gain much for development. This

enjoins that they cannot let the totality of institutions and practices mainly to absorb technology for the purpose of a development path to integrate with centres of new technology producers. They need to build also institutions and practices for own innovation capability that is internally generated without closing learning from outside.

Globelics has combined together knowledge, innovation, learning and capability building and suggested research applicable to the problems of development and underdevelopment by translating innovation systems into: "learning, innovation and capacity, capability and competence building systems" that creates internal and indigenous innovative capabilities as well as absorptive capabilities of new technologies from the industrial economies. This opens up a possible line of inquiry where neither the innovation creator capability nor the absorptive capability are stressed separately but in combination, where for development that integrates with the technology centres of the world to occur, both endogenous and absorptive innovative capabilities are necessary conditions, though they may not be sufficient.

There is thus a need to comprehend national system of innovation to include both endogenous and absorptive capabilities to generate an alternative development model. The alternative economic framework that combines domestic and foreign, national and international, internal and external

Figure 2: Major aspects/components of National Technology System in Developing Countries



innovative capabilities can be captured by processes that generate "learning, innovation and competence building systems" resulting in something like a "national innovation learning and development systems" (NILDS). This inclusive conceptualization that makes developing countries to emerge as both suppliers of innovation and absorbers of created or transferred technologies can mobilize both the potential resources and knowledge from within whilst remaining open and actively searching for the knowledge from outside. The national learning, innovation and development systems can address the problems and challenges of transition from underdevelopment to development for the developing world, the BRICS (emerging economies – Brazil, Russia, India, China, and South Africa) and others such as Mexico.

It is evident from the experiences of countries like Korea and India (e.g. space technology) that systems of innovation in developing countries could focus on developing both endogenous and absorptive capabilities (Kim, 1993, 1996; Baskaran 1998, 2001a, 2001b).

4. Similarities and Differences between NSI and NTS

The NSI has four key sets of elements. The first set involves the ideas and policies that frame the overall scope or possible sets of interactions given the internal and external social and economic constraints facing a particular NSI.

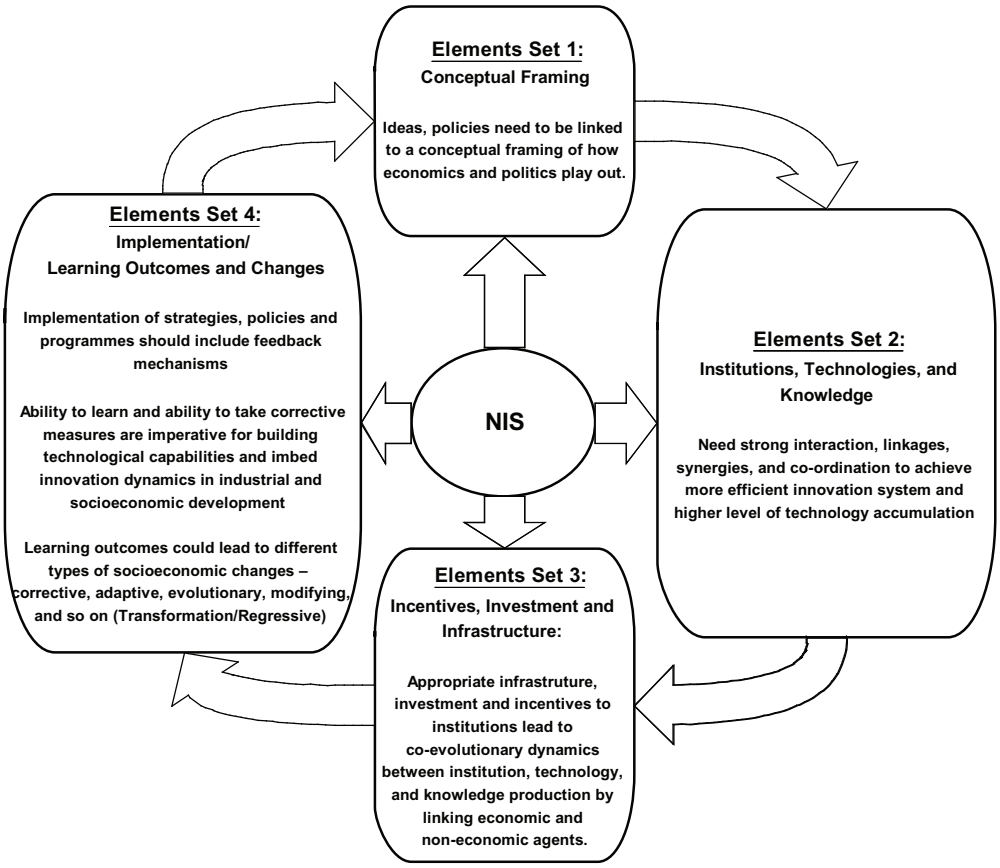
The second set involves the choice or the selection and actual construction or implementation of the set of interactions that bring to bear the conceptual framing and policies selected above (the first set) with the institutions and elements that interact to build the NSI.

The third set involves the means provided to the institutions (second set) for realizing the goals set (first set), that is, various incentives such as financial and social rewards. This is vital to foster appropriate incentive system which is consistent with the goals and objectives set and is seen as fair and legitimate and command wider acceptance by various components forming the NSI. If the incentive system is inappropriate or fails to command wider acceptance, the opportunity to organize robust NSI system and achieve measureable results will be put in jeopardy.

The fourth set highlights the overall efficiency of the environment for learning in terms of implementation, monitoring, review, and feedback involving the above three sets. The learning outcomes can be different such as transformative, adaptive, corrective, modifying, evolutionary, redesigning, and so on. This can also be negative. The relationships between these four sets of elements that constitute NSI are illustrated by Figure 3.

The problem with the NTS concept is that the components that interact, that is, the actors (the helices), the policy setting, the institutions, the

Figure 3: Four major sets of elements of National System of Innovation (NSI)



knowledge and the incentives will build learning, innovation and competence primarily to absorb knowledge, innovation, technology and not for their creation and initiation. The bias in building institutions and policy competencies for technology procurement leaves a yawning gap in the need to create universities, governments and industries and their interactions to create new technologies. Whilst it is important countries should not try to reinvent the wheel, it is even more important that they build the internal transformative capability which is essential also to sustain the absorptive and selection internal capability for acquiring, using ad diffusing new technologies.

The problem is that building internal research capacity, spending R&D and other resources for creating innovation is more expensive than the resources that may be needed including the time it takes to absorb and procure new technology.

The problem may also be related to the possible deployment of human resources to learn what others have created rather than to deploy resources for creating new technologies.

If it is possible from acquired technology, an endogenous innovation can be stimulated the learning from the outside may be an easier route.

Since there is no free new technology market, it may not be easy for poorer economies to acquire technologies which may be enabling of creating indigenized innovation systems.

The drawback could lead to dependency and a low technology trap which can lead to a vicious circle. Though it may be costly it may not be wise to abandon the search to indigenize innovation systems by building in a sustained manner and frame the elements and their interactions to lay the foundation of a national system of innovation that combines creation capable of also absorption. It seems creation of innovation can serve better the absorptive capability, whereas lack of creation of an endogenous innovation system may also weaken the capability to import, absorb and modify new technology diffusion.

A national system of innovation must be open to knowledge, innovation and new technology from outside. It cannot be built without interaction and exposure to the available trends in world science, technology and innovation.

A national technology system cannot sustain itself unless the acquired technology from outside can contribute sooner or later to an internal endogenous innovation system capable of self-reproduction.

What is required is at the conceptual level to say neither stress on creation internally or absorption and import of new technologies externally. What is needed is to create actors, polices, institutions, knowledge and incentives capable of combining both, that is creating innovation and absorbing innovation to help strengthen the internal and endogenous system. A number of countries in Africa have innovation plans. South Africa has a ten year innovation plan where the Government uses a number of policies to enhance an internally generated innovation environment as a launch pad for an independent integration in the world technology circuits (DST, 2008). Some countries like Botswana wish to increase their R&D from its current less than half of 1% to 1 % of GDP in five years!

What it means is that countries that plan to develop their national innovation system will differ if they plan to be innovation producers and absorbers or mainly absorbers and not innovation creators. This has impact on the totality of their practices, plans, policies and institutions.

5. A Reconciliation of NSI and NTS: The Globelics[6] Synthesis with NILDS

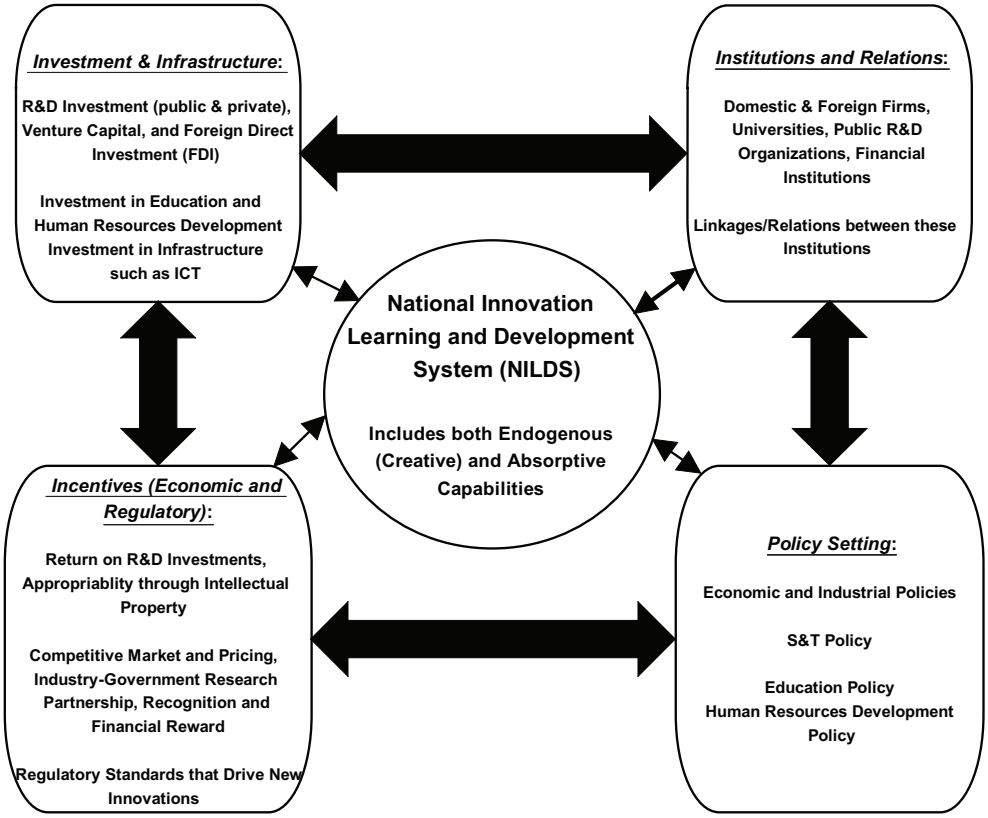
If we proceed with the search and selection of an alternative framework that employs innovation systems perspectives on the problems of development and underdevelopment, what we end up doing is centring both knowledge

and innovation as the drivers and focusing devices for providing orientation, dynamics and practices to actors, policy choices, institutions and incentives for undertaking economic activities. We end up contextualizing innovation within economic development or dynamics. This reorientation of economic development where innovative creative destruction is central in a developing economy context may thus provide a resource to advance theoretical knowledge further. This can be done by consciously developing linkages and combinations between economic and non-economic structure and actors, formal theories and appreciative theories, awareness and learning in connection between the tools used in each type of theorizing, deepening evolutionary economic dynamics to include new thematic areas such as national economic integration in relation to reducing dependency on donors in different types of developing and transition economies, finding productive linking internal and external, domestic and international, political and economic, and empirical and policy changes and approaches in different national economic settings.

We attempt to present this through the concept of 'national innovation learning and development systems' (NILDS) that includes both endogenous and absorptive capabilities to generate an alternative development model. This inclusive conceptualization emphasizes on developing countries emerging as both suppliers of innovation and absorbers of created or transferred technologies from outside. The NILDS can address the problems and challenges of transition from underdevelopment to development for the developing world, including emerging economies such as the BRICS and others. Figure 4 illustrates the concept of NILDS by synthesizing the NSI and NTS.

The problem with the NTS concept is that the components that interact such as the actors (the helices), the policy setting, the institutions, the knowledge and the incentives will build learning, innovation and competence primarily to absorb knowledge, innovation, technology and not for their creation and initiation. The bias in building institutions and policy competencies for technology procurement leaves a yawning gap in the need to create universities, governments and industries and their interactions to create new technologies. Important issues arise where each of the components have quality standard to be universities, industries and Governments. The latter must be able to regulate and frame the overall developmental trajectory of a country's economy. Universities must produce quality trained human capital and knowledge in terms of peer reviewed publications, patents and innovations. Industries must produce products that can fetch commercial profit. Both the capability and the institutional strength cannot be taken for granted of each of these helices. They must be evaluated and pass a quality and capability notional test with the benchmark provided by those who both create and absorb new technologies, and those that create mainly, and those

Figure 4: National Innovation Learning and Development System (NILDS): The Globelics Synthesis reconciling NSI and NTS



that do not create but are capable of absorbing. Whilst it is important countries should not try to reinvent the wheel, it is even more important that they build the internal transformative capability which is essential also to sustain the absorptive and selection internal capability for acquiring, using or diffusing new technologies.

The creation of innovation requires that at least a country must have one research university or specialized research institutes. The researchers require resources, other researchers, experience, knowledge, ideas, creativity, skills, equipment, materials and above all time. Their research output can be produced to meet either commercial or non-commercial purposes. If they are products, services and processes they may be commercialized. If the research produce knowledge for capability, theories, discoveries, new methods, they may be used for further research and training. Even knowledge that appears in patents and publications may not be commercialized. The institutional arrangement that facilitates a research system equipped with research inputs to create research outputs, research outcomes, and impacts across the economy is essential for knowledge, innovation and technology creation, diffusion,

adoption to sustain a transformation process capable of transition to the level and stage of industrial economies.

The problem is that building internal research capacity, spending R&D and other resources for creating innovation is more expensive than the resources that may be needed including the time it takes to absorb and procure new technology.

The problem may also be related to the possible deployment of human resources to learn what others have created rather than to deploy resources for creating new technologies.

If it is possible from acquired technology and endogenous innovation can be stimulated the learning from the outside may be an easier route.

Since there is no free new technology market, it may not be easy for poorer economies to acquire technologies which may be enabling of creating indigenized innovation systems.

The drawback could lead to dependency and a low technology trap which can lead to a vicious circle. Though it may be costly it may not be wise to abandon the search to indigenize innovation systems by building in a sustained manner and frame the elements and their interactions to lay the foundation of a national system of innovation that combines creation capable of also absorption. It seems creation of innovation can serve better the absortive capability, whereas lack of creation of an endogenous innovation system may also weaken the capability to import, absorb and modify new technology diffusion.

A national innovation system must be open to knowledge, innovation and new technology from outside. It cannot be built without interaction and exposure to the available trends in world science, technology and innovation.

A National Technology System cannot sustain itself unless the acquired technology from outside can contribute sooner or later to an internal endogenous innovation system capable of self-reproduction and relatively autonomous self-generation driven by an innovative developmental dynamics.

What is required is at the conceptual level to say neither stress on creation internally or absorption and import of new technologies externally. What is needed is to create a totality of actors, polices, institutions, knowledge and incentives capable of combining both, that is creating innovation and absorbing innovation to help strengthen the internal and endogenous system to sustain both creation and absorptive capacities simultaneously.

6. Concluding Remarks

The strength of the NTS conceptual framework is that it suggests the totality of public and private institutions, actors, policy settings and incentives necessary for follower developing nations that are relevant for helping them to

integrate better with the world leaders in new technology. This insight which has both empirical and conceptual substantiation is indeed a big contribution in its own right. The concept recognizes a technology gap and an uneven economic context distinguished by the disparity in the concentration of innovation in the leading industrial countries and paucity of self-regenerative innovative activities in developing countries. It suggests how those who lack innovation may be able to organize their technology system to integrate in the knowledge, innovation and learning economy.

Where the NTS is weak is in not being able to fully recognize that the innovation system must also be organized to create innovation also not just to absorb already created innovation elsewhere. If an economic context where innovation is relevant is also important for developing economies for their economic growth, the effort to create and absorb innovation and in fact to absorb in order to create and conversely to create in order to absorb new technology is essential to undertake simultaneously with appropriate resource allocation, institutional coordination, incentives and policy integration and their coherent interactions.

Evolutionary economics provided a theoretical alternative by its critique of neoclassical economics theory as a theory "that cannot deal adequately with an economic context in which innovation is important."[7]

Like evolutionary economics, the NSI concept also encouraged conceptual and empirical focus away from the linear model's policy for science, support for R&D and support for specific sectors. It drew attention to the systemic features of innovation processes where national policies, history, context, institutions, norms, cultures, geographical variations and actors matter for economic development. It has now become an established paradigm to understand innovation systems with interacting elements, systems and geographical boundaries. It has evolved mainly from the totality of practices of industrial economies. It can cast its net to encompass the developing world with the possible risk that it may be accused of conceptual looseness. But while NSI can be used for any nation in the world, there is a need to develop a specific focus on the distinction between developing country technology-innovation followers and developed country technology-innovation leaders.

We suggest an alternative formulation that can capture innovation processes within economic development processes and conversely development processes within innovation processes, i.e. innovation internalized in the context of economic growth and development within developing economies. If we wish to capture this dynamic, there is a need for an alternative conceptual framework of NILDS or a national innovation and development system which can address both the issues raised by NTS and NSI and go beyond their relative weaknesses and strengths, i.e. the creation and absorption dichotomy of NTS and the mainly industrial economy or already functioning innovation

system as opposed to the need to understand and explain how to make, forge and build innovation systems where it may not hardly exist as expected!

The value of this new concept is three fold: to integrate innovation creation with the capacity for innovation absorption and integrate these efforts by building institutions for knowledge provision to both create and absorb or to create in order to absorb or absorb in order to create new technologies and innovations.

The second is to re-focus NSI to include not only those that are already with systems of innovation but also those which are trying to build or make them by starting from a low level of economic development.

The third is to counter the possible dependency on donors that building NTS for absorbing new technology is likely to engender. A national system of technology and innovation must also make the countries to be self-reliant and independent. A concept that explicitly introduces the need to organize systems, incentives, policies, institutions for knowledge creation and absorption at a national level is needed to address donor dependency.

The last but not least matter is the importance of organizing the knowledge producing research system such as universities to become pivotal in creating productive power and the capital of the mind. The existence of the latter in the form of at least one research university in a developing economy is critical to both innovation creation and absorption and wealth creation and development.

It is on the foundation of integrated processes of innovation with the processes of development that structural transformation of developing country followers can occur to realize the full benefit of integration with world technology leaders on the basis of autonomy and a specific national economy's own agency.

Innovation creators and innovation absorbers in a developing country context require different institutional, network, policy, actors, human resources, incentive matrix and capabilities. Innovation creators can absorb new technologies, as most of the new technology trade has been largely between the triad group of countries such as USA, Japan and EU and the new and the emerging BRICS and earlier East Asian Tigers. But, the innovation absorbers from outside the technology frontiers *may or may not* become innovation creators. This may not be true for all innovation absorbers, but those in the lower rungs of the development ladder may remain more dependent than becoming independent.

The question is whether technology absorbers can also be made technology creators left to policies aimed at absorbing new technologies from those in the technology frontier with the expectation of a technology trickle down eventually to become and provide a technology creation potential as the developing economies are able to integrate in the world technology frontiers.

If we harbour doubt that trickle down in technology is as difficult as trickle down in economics from the structural adjustment policies, then we need to start thinking out of the technology absorption box. If we enter a new box for technology creation to go side by side with efforts at absorption, we need to frame our conceptual tools differently.

That requires at the very outset we cannot let go the opportunity of combining creation of technology with absorption of technology for the main goal of creating innovation systems that orientate policies, knowledge, actors, incentives and institutions and their interactions to accelerate economic development. This means, conceptually, there is a need, from the beginning, for innovation processes to be integrated with development processes and the vice versa for identifying, defining, selecting and building the totality of institutions, policies, actors, knowledge and incentives to enable developing country followers to join the new technology leaders.

We suggest the NILDS concept provides the approach and frame for integrating innovation, learning and competence building with development, knowledge with development and new technologies with development. Together these provide all the relevant approaches needed to stimulate and drive economic development in low income countries by orientating all the relevant actors, institutions and policies and their interactions to make a dynamic system that self reproduces itself by navigating through external and internal constraints with knowledge, learning and innovation as the key drivers of economic development.

Notes

1. We did not categorize it as a fourth since the communities that work with evolutionary economics and NSI and those with Triple Helix often work separately and not as one community though they are familiar with each others work and may be participating in each other respective forums at various times.
2. The Triple Helix will have its VII conference at the University of Strathclyde, Glasgow, June 17-19, 2009. There is also an Ethiopian Triple Helix association which has sponsored a special conference at the United Nation Conference Centre in Addis Ababa, from May 29 to 31, 2006. There is also a journal of Triple Helix with a web site: http://www.ethiopiantriplehelixassociation.org
3. *Ibid.*
4. Mario Scerri and Richard Nelson both deserve acknowledgment for reading this paper and provide constructive criticisms and feedback. Mario suggested that NSI has now become a general theory or paradigm as part of the evolutionary economics alternative to neoclassical economics. Richard Nelson suggested that a tight distinction between appreciative and formal theories may send the wrong message that appreciative cannot inspire formal theorizing and the vice versa. He says he does both and suggests the more interesting search is how each is relevant to the other (personal communication).

5. Some have criticized the NSI approach as both too broad and insufficiently theorized (e.g. see Radosevic, 1998; Whitely, 1998).
6. When we say Globelics it gives the impression of a homogenous community with a shared understanding or view and orientation that include all the diverse scholars of all those in the network. That is not what is meant by the Globelics synthesis. Globelics has innovation and development as one important focus of its scholarly programme. But this work is one of many important focus areas. It also works on geography, labour market, management, human resources and a host of other issues that it deals with now and may take on in the future. By the Globelics synthesis here we mean the effort made by Lundvall and others to explicitly incorporate development concerns by extending the NSI into what they termed as Learning and Innovation and competence building systems within the NSI framework. We have broadened this into a National Innovation Learning and Development System framework (NILDS). We do not expect or imply that all in Globelics as a community share this understanding we suggest here in this paper.
7. See Richard Nelson's paper: "Economic Development from the Perspective of Evolutionary Theory" adapted from his keynote address presented at the October 2004 Meeting of Globelics, held in Beijing, China.

References

Abramovitz, M. (1986) "Catching Up, Forging Ahead, and Falling Behind", *Journal of Economic History*, 46: 386-406.

Baskaran, A. (1998) "Technology Development in India's Space Programme 1965-1995: The Impact of the Missile Technology Control Regime", PhD Thesis, Science Policy Research Unit, University of Sussex, and Brighton, UK.

Baskaran, A. (2001a) "Competence Building in Complex Systems in the Developing Countries: The Case of Satellite Building in India", *Technovation*, 21(2): 109-121.

Baskaran, A. (2001b) "Technology Accumulation in India's Space Program Ground Systems: The Contribution of Foreign and Indigenous Inputs", *Technology in Society*, 23(1): 195-216.

Baskaran, A. and Muchie, M. (eds) (2006) *Bridging the Digital Divide: Innovation Systems for ICT in Brazil, China, India, Thailand and Southern Africa*, London: Adonis-Abbey.

Baskaran, A. and Muchie, M. (2007) "The Impact of the National Innovation Systems on the Flow and Benefits of Foreign Direct Investment to National Economies", DIIPER Working Paper Series, Aalborg University, Denmark.

Baskaran, A and Muchie, M. (2008) "Foreign Direct Investment and Internationalization of R&D: The Case of BRICS Economies", The 5th ASIALICS International Conference: "From Manufacturing to Services: Changing Role of Innovation Systems", April 2-4, Bangalore, India.

Chang, Ha-Joon (2002) *Kicking Away the Ladder: Development Strategy in Historical Perspective*, London: Anthem Press.

Department of Science and Technology (DST) – Republic of South Africa (2008) *Innovation Towards a Knowledge-Based Economy*, Pretoria: Government Press.

Dosi, G., Freeman, C., Nelson, R., Silverberg, G. and Soete, L. (eds) (1988) *Technical Change and Economic Theory*, New York: Pinter.

Edquist, C. (1997a) *Systems of Innovation*, London: Frances Pinter.
Edquist, C. (ed.) (1997b) *Systems of Innovation: Technologies, Institutions and Organizations*, New York: Pinter.
Edquist, C. (2001) "Systems of Innovation for Development", Background paper for Chapter 1: "Competitiveness, Innovation and Learning: Analytical Framework" for the *UNIDO World Industrial Development Report* (*WIDR*).
Etzkowitz, H. (2002) *MIT and the Rise of Entrepreneurial Science*, London: Routledge.
Etzkowitz, H. and Leydesdorff, L. (1997) *Universities in the Global Economy: A Triple Helix of Academic-Industry-Government Relations*, London: Croom Helm.
Etzkowitz, H. and Leydesdorff, L. (2000) "The Dynamics of Innovation: From National Systems and 'Mode 2' to a Triple Helix of University-Industry-Government Relations", *Research Policy*, 29(2): 109-123.
Fagerberg, J. and Godinho, M. (2005) "Innovation and Catching Up", in Fagerberg, J., Mowery, D.C. and Nelson, R.R. (eds), *The Oxford Handbook of Innovation*, Oxford: Oxford University Press.
Freeman, C. (1982) "Technological Infrastructure and International Competitiveness", Draft paper submitted to the OECD ad hoc-group on Science, Technology and Competitiveness, August, mimeo.
Freeman, C. (1987) *Technology, Policy, and Economic Performance: Lessons from Japan*, New York: Pinter.
Freeman, C. (1995) "The 'National System of Innovation' in Historical Perspective", *Cambridge Journal of Economics*, 19(1): 5-24.
Freeman, C. (2002) "Continental, National and Sub-national Innovation Systems – Complementarity and Economic Growth", *Research Policy*, 31: 191-211.
Gerschenkron, A. (1962) *Economic Backwardness in Historical Perspective: A Book of Essays*, Cambridge, Mass.: Belknap.
Johnson, C. (1982) *MITI and the Japanese Miracle: The Growth of Industrial Policy, 1925-1975*, Stanford, CA: Stanford University Press.
Kim, L. (1993) "National System of Industrial Innovation: Dynamics of Capability Building in Korea", in Nelson, R.R. (ed.), *National Innovation System: A Comparative Analysis*, New York: Oxford University Press.
Kim, L. (1996) *From Imitation to Innovation: Dynamics of Korea's Technological Learning*, First draft, Brighton: Science Policy Research Unit, University of Sussex.
Lall, S. (2000) "Selective Industrial and Trade Policies in Developing Countries: Theoretical and Empirical Issues", Queen Elizabeth House Working Paper Series, No. 48, Oxford, UK.
Lall, S. (2001) *Competitiveness, Technology and Skills*, Cheltenham, UK: Edward Elgar Publishing.
Lall, S. (2003) "Indicators of the Relative Importance of IPRs in Developing Countries", *Research Policy*, 32(9): 1657-1680.
Lall, S. and Pietrobelli, C. (2002) *Failing to Compete: Technology Development and Technology Systems in Africa*, Cheltenham, UK: Edward Elgar Publishing.
Lall, S. and Pietrobelli, C. (2005) "National Technology Systems in Sub-Saharan Africa", *International Journal of Technology and Globalization*, 11(3-4): 311-342.

Lall, S. and Urata, S. (eds) (2003) *Competiveness, FDI and Technological Activity in East Asia*, Cheltenham: Edward Elgar.

List, F. (1885) *The National System of Political Economy*, trans. from the original German edn. (1841), London: Longmans, Green and Company.

Lundvall, B.A. (1988) "Innovations as in Interactive Process: From User-Producer Interaction to the National System of Innovation", in Dosi, G., Freeman, C., Nelson, R., Silverberg, G. and Soete, L. (eds), *Technical Change and Economic Theory*, New York: Pinter.

Lundvall, B.A. (ed.). (1992) *National Systems of Innovation*, London: Pinter.

Lundvall, B.L., Johnson, B., Andersen, E.S., and Dalum, B. (2002) "National Systems of Production, Innovation and Competence Building", *Research Policy*, 31(2): 213-231.

Muchie, M., Gammeltoft, P., and Lundvall, B.A. (eds) (2003) *Putting Africa First: The Making of African Innovation System*, Aalborg, Denmark: Aalborg University Press.

Nelson, R. (ed.) (1993) *National Innovation Systems: A Comparative Analysis*, New York: Oxford University Press.

Nelson, R. and Winter, S. (1982) *An Evolutionary Theory of Economic Change*, Cambridge: Harvard University Press.

OECD (1997) *National Innovation Systems*, Paris: OECD. See <http://www.oecd.org/dataoecd/35/56/2101733.pdf>

OECD (1999) *Managing National Systems of Innovation*, Paris: OECD.

OECD (2005) *Governance of Innovation Systems: Synthesis Report*, Vol. 1, Paris: OECD. See <http://www.consejodeinnovacion.cl/cnic/servicios/documentos/web/download.php?id=49>

Radosevic, S. (1998) "Defining Systems of Innovation: A Methodological Discussion" *Technology in Society*, 20: 75-86.

Schumpeter, J.A. (1911) *Theorie der wirtschaftlichen Entwicklung: Eine Untersuchung uber Unternehmergewinn, Kapital, Kredit, Zins und den Konjunkturzyklus*, Leipzig: Duncker & Humblodt.

Schumpeter, J.A. (1934) *The Theory of Economic Development: An Inquiry into Profits, Capital, Credit, Interest and Business Cycle*, London: Oxford University Press.

Schumpeter, J.A. (1939) *Business Cycles*, New York: McMillan.

Schumpeter, J.A. (1942) *Capitalism, Socialism and Democracy*, London: Allen & Unwin.

UNCTAD (2003) *Investment and Technology Policies for Competitiveness: Review of Successful Country Experiences*, New York and Geneva: United Nations.

UNIDO (2002) Industrial Development Report 2002/2003: Competition through Innovation and Learning, Vienna: United Nations Industrial Development Organization.

Veblen, T. (1915) *Imperial Germany and Industrial Revolution*, New York: Macmillan.

Veblen, T. (1919) *The Place of Science in Modern Civilization and Other Essays*, New York: Augustus M. Kelley.

Whitley, R. (1998) "Innovation Strategies, Business Systems and the Organization of Research", Paper prepared for the Sociology of Science Yearbook Meeting, Krusenberg, Sweden, 24-27 September.